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Mongolodiaptomus nakhonphanomensis sp. nov. (Copepoda, Calanoida, Diaptomidae) from north-eastern Thailand, with a note on *M. pectinidactylus* (Shen & Tai, 1964)

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Abstract

A new species of diaptomid copepod, *Mongolodiaptomus nakhonphanomensis* **sp. nov.**, is described from surface water bodies in Nakhon Phanom Province, north-eastern Thailand. The new species is assigned to the *M. mephistopheles* (Brehm, 1933) species group and is morphologically most similar to *M. pectinidactylus* (Shen & Tai, 1964), a rare species in Thailand. It can be distinguished from *M. pectinidactylus* by the following characters: I) In females, the new species has asymmetrical lateral wings on pediger 5 and the second exopod of the fifth leg, whereas *M. pectinidactylus* (Shen & Tai, 1964) shows symmetry in these structures; II) the female of the new species has a shorter and more robust seta on the second exopod of the fifth leg compared to that of *M. pectinidactylus*; III) in males, the new species lacks a spinular row on the basis of the right fifth leg, which is present in *M. pectinidactylus*; IV) the second exopod of the male fifth leg in the new species is distally expanded, whereas it is oblong in *M. pectinidactylus*; V) the lateral spine of the second exopod of the male fifth leg is bent outwards in the new species, whereas it is straight in *M. pectinidactylus*. A brief re-description of *M. pectinidactylus* and a comparison with the new species are provided. This discovery raises the number of recognised species in the genus *Mongolodiaptomus* to fifteen worldwide. A biogeographical map is also presented.

Key Words

Endemic species, Indo-malayan realm, *M. pectinidactylus*, Songkhram River Basin

Introduction

The genus *Mongolodiaptomus* Kiefer, 1937 is primarily distributed in inland regions of Southeast Asia (SEA) and represents the most diverse diaptomid genus in Thailand (Sanoamuang and Koompoot 2024). Six species have more extensive ranges, reaching northwards into south China (Guangdong, Guangxi and Hainan Provinces): *M. birulai* (Rylov, 1923), *M. calcarus* (Shen & Tai, 1965), *M. formosanus* Kiefer, 1937, *M. gladiolus* (Shen & Lee, 1963), *M. pectinidactylus* (Shen & Tai, 1964) and *M. uenoi* (Kikuchi, 1936). Amongst these, only *M. birulai* (Rylov, 1922) has been reported as far north as central China (Hunan Province), north China (Hebei and Heilongjiang Provinces) and east China (Fujian, Jiangsu and Zhejiang Provinces), as well as Taiwan (Li et al. 2018). In addition, three species have been recorded from cave habitats: *M. botulifer* (Kiefer, 1974) and *M. malaindosinensis* (Lai & Fernando, 1978) (Thailand) and *M. birulai* (Rylov, 1923) (China) (Li et al. 2018; Watiroyram 2021).

Two species remain doubtful and are subject to differing opinions amongst taxonomists regarding whether they represent distinct species or are synonyms, namely *M. birulai* and *M. formosanus* (Li et al. 2018; Sanoamuang and Watiroyram 2018; Ranga Reddy et al. 2000; Sanoamuang and Koompoot 2024). Examination of material from both species is required in future studies to clarify their taxonomic status. Due to the lack of speci-

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men examination and the absence of detailed published descriptions supporting their status, we follow the World Copepoda Database in recognising them as distinct species in the present study (Walter and Boxshall 2025). Thus, there are currently 14 previously known species worldwide, including ten recorded from Thailand, with the exception of *M. birulai*, *M. formosanus*, *M. gladiolus* and *M. mephistopheles* (Brehm, 1933) (Sanoamuang and Koompoot 2024; Walter and Boxshall 2025).

During our examination of samples collected from tributaries of the Mekong River Basin in Thailand, eight known and one undescribed species of *Mongolodiaptomus* were recorded (Koompoot and Watiroyram 2025). Most of *Mongolodiaptomus* species previously reported from the country, except *M. phutakaensis* Sanoamuang & Koompoot, 2024, were found during this field trip, providing an excellent opportunity for an intensive taxonomic study. This resulted in clear morphological differentiation amongst closely-related species, along with changes in species composition and distribution (Koompoot and Watiroyram 2025). These findings led to the description of a new species, as well as the recording of *M. pectinidactylus* (Shen & Tai, 1964), a rare species observed in the present study. A biogeographic map of the genus *Mongolodiaptomus* is also presented, based on available published literature.

Materials and methods

Site description

The Nawa District, situated in the westernmost part of the Nakhon Phanom Province in Thailand, comprises six sub-districts and spans an area of approximately 520 km^2 (Fig. 1A, B). It is one of twelve districts across three provinces located in the lower floodplain of the Songkhram River Basin (Blake and Pitakthepsombut 2006). The Songkhram River is a major tributary of the Mekong River that flows through the northern part of north-eastern Thailand. It originates in the Sakhon Nakhon Province and flows eastwards through the Udon Thani, Sakhon Nakhon and Bueng Kan Provinces before joining the Mekong River at Ban Chai Buri City in the Nakhon Phanom Province (Hortle and Suntornratana 2008).

Sampling and specimen preparation

Forty-eight sampling sites across six sub-districts of the Nawa District were selected for copepod collection conducted between July and August 2023 (Fig. 1A, B). Samples were collected qualitatively using a hand net and a plankton net with a 60 µm mesh size from various types

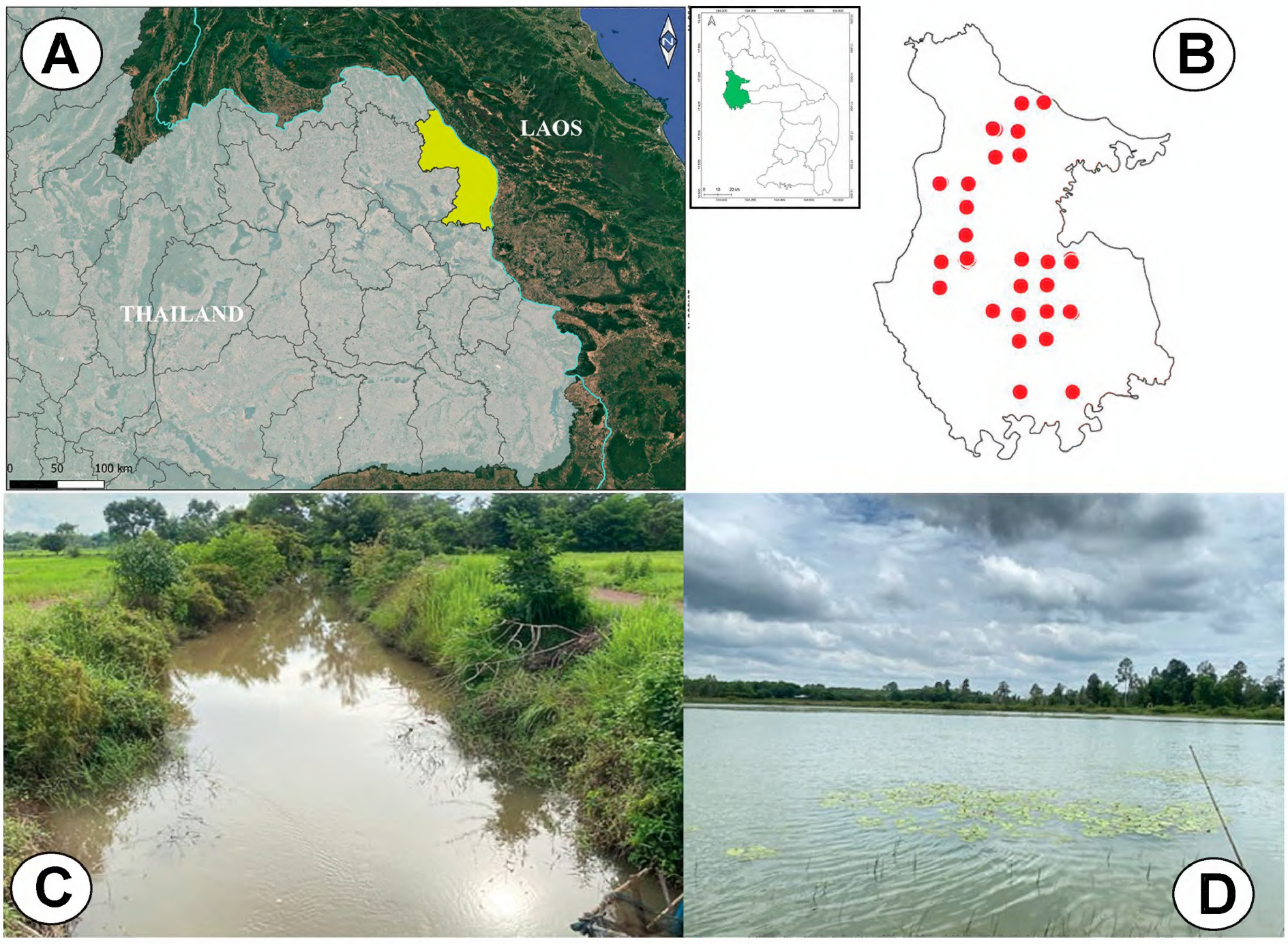

Figure 1. Sampling site and two habitats of *Mongolodiaptomus nakhonphanomensis* sp. nov.: **A.** Location of the Nakhon Phanom Province in the north-eastern Thailand (indicated in yellow); **B.** Location of the Nawa District within the Nakhon Phanom Province (indicated in green) and sampling sites (indicated in red spots); **C.** Irrigation canal (temporary waterbody); **D.** Permanent pond.

of waterbodies, including rice fields, roadside canals, irrigation canals, buffalo bogs, ponds and reservoirs (Fig. 1C, D). Samples were immediately fixed in approximately 5% formalin on spot. Water quality parameters, including pH, temperature, conductivity and total dissolved solids (TDS), were measured at each sampling site using a multiprobe device (Laqua Horiba, WQ-310-K). Adult animals were picked out and preserved with 70% ethanol in 1.5ml microtubes in the laboratory. Adult specimens were dissected under an Olympus SZ51 stereomicroscope in a mixture of glycerol and 70% ethanol (ratio ~ 1:10 v/v). Dissected specimens were mounted in pure glycerol and sealed with transparent nail polish. Permanent slides with dissected animals were examined with an Olympus compound microscope (CX31) at 1000 times magnification. Pencil drawings were produced with a drawing tube (Olympus U-Da) mounted on a compound microscope. The drawings were subsequently scanned and finalised using the graphic software Procreate version 1.1. Specimens were selected for scanning electron microscopy (SEM) and photographed using a LEO 1450 VP scanning electron microscope, following the protocol of Watiroyram and Sanoamuang (2017).

The morphological terminology follows Huys and Boxshall (1991). Type specimens are deposited at the Thailand Natural History Museum, Pathum Thani, Thailand (**THNHM**) and the Nakhon Phanom University, Faculty of Science, Thailand (**NPU**).

Abbreviations

The following abbreviations are used throughout the text and figures: **a**, aesthetasc; **Enp**, endopod; **Exp**, exopod; **Exp/Enp-n**, exopodal segment n/endopodal segment n; **P1–P5**, swimming legs 1–5; **s**, spine (s).

Associated fauna

In total, during the study, fourteen species of Calanoida and six species of Cyclopoida were identified (Table 1). Amongst the species recorded, *Mongolodiaptomus nakhonphanomensis* sp. nov. is new to science and is described herein. The most frequently encountered species were *Mongolodiaptomus malaindosinensis*, *Eodiaptomus draconisignivomi*, *Mesocyclops affinis*, and *M. thermocyclopoides*.

Taxonomic section

Order Calanoida Sars, 1903
Family Diaptomidae Baird, 1850
Genus *Mongolodiaptomus* Kiefer, 1937

***Mongolodiaptomus nakhonphanomensis* sp. nov.**

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Figs 2–7

Type locality. A pond in the Nong Hua Ngua Village (Fig. 1D), Na Khun Yai Sub-district, Na Wa District, Nakhon Phanom Province, north-eastern Thailand; coordinates: 17°30'01.47"N, 104°08'03.35"E, altitude: 153 m above sea level.

Material examined. ***Holotype*:** one adult male dissected and mounted on one slide (THNHM-IV-21117); allotype: one adult female dissected and mounted on one slide (THNHM-IV-21118); ***paratypes*:** three adult males and three adult females dissected and mounted on one slide each (NPU 2025–01-04). All specimens collected from the type locality on 30 July 2023 by Piyathida Monongdern.

Etymology. The specific name *nakhonphanomensis* refers to Nakhon Phanom Province in north-eastern Thailand, where the new species was discovered. The Latin suffix "-ensis" denotes origin or place.

Description. ***Adult male*.** Body length excluding caudal setae 2.1 mm (holotype) (other males: mean = 2.0, n = 3) (Fig. 2A). Rostrum (Fig. 1B) with two spiniform processes. Pedigers 4 and 5 incompletely fused laterally (Fig. 1A). Lateral wings (Fig. 2A) asymmetrical: left wing prolonged downwards, the right wing expanded distally in lateral direction; both tipped with thin spine. Urosome (Fig. 2E) orientated obliquely posteriad towards right side. Genital somite short, asymmetrical, with small

Table 1. Copepod species recorded from the study area.

Calanoid species	Cyclopoid species
1. *Dentodiaptomus javanus* (Grochmalicki, 1915)	1. *Mesocyclops affinis* Van de Velde, 1987
2. *Eodiaptomus draconisignivomi* Brehm, 1952	2. *M. thermocyclopoides* Harada, 1931
3. *E. phuphanensis* Sanoamuang, 2001	3. *Microcyclops rubellus* (Lilljeborg, 1901)
4. *E. sanoamuangae* Ranga Reddy & Dumont, 1998	4. *Thermocyclops crassus* (Fischer, 1853)
5. *Heliodiaptomus elegans* Kiefer, 1935	5. *T. decipiens* (Kiefer, 1929)
6. *Mongolodiaptomus botulifer* (Kiefer, 1974)	6. *T. wolterecki* Kiefer, 1938
7. *M. dumonti* Sanoamuang, 2001	
8. *M. malaindosinensis* (Lai & Fernando, 1978)	
9. *M. nakhonphanomensis* sp. nov.	
10. *M. pectinidactylus* (Shen & Tai, 1964)	
11. *Neodiaptomus yangtsekiangensis* Mashiko, 195	
12. *Phyllodiaptomus parachristineae* Sanoamuang & Watiroyram, 2023	
13. *P. praedictus* Dumont & Ranga Reddy, 1994	
14. *Vietodiaptomus blachei* (Brehm, 1951)	

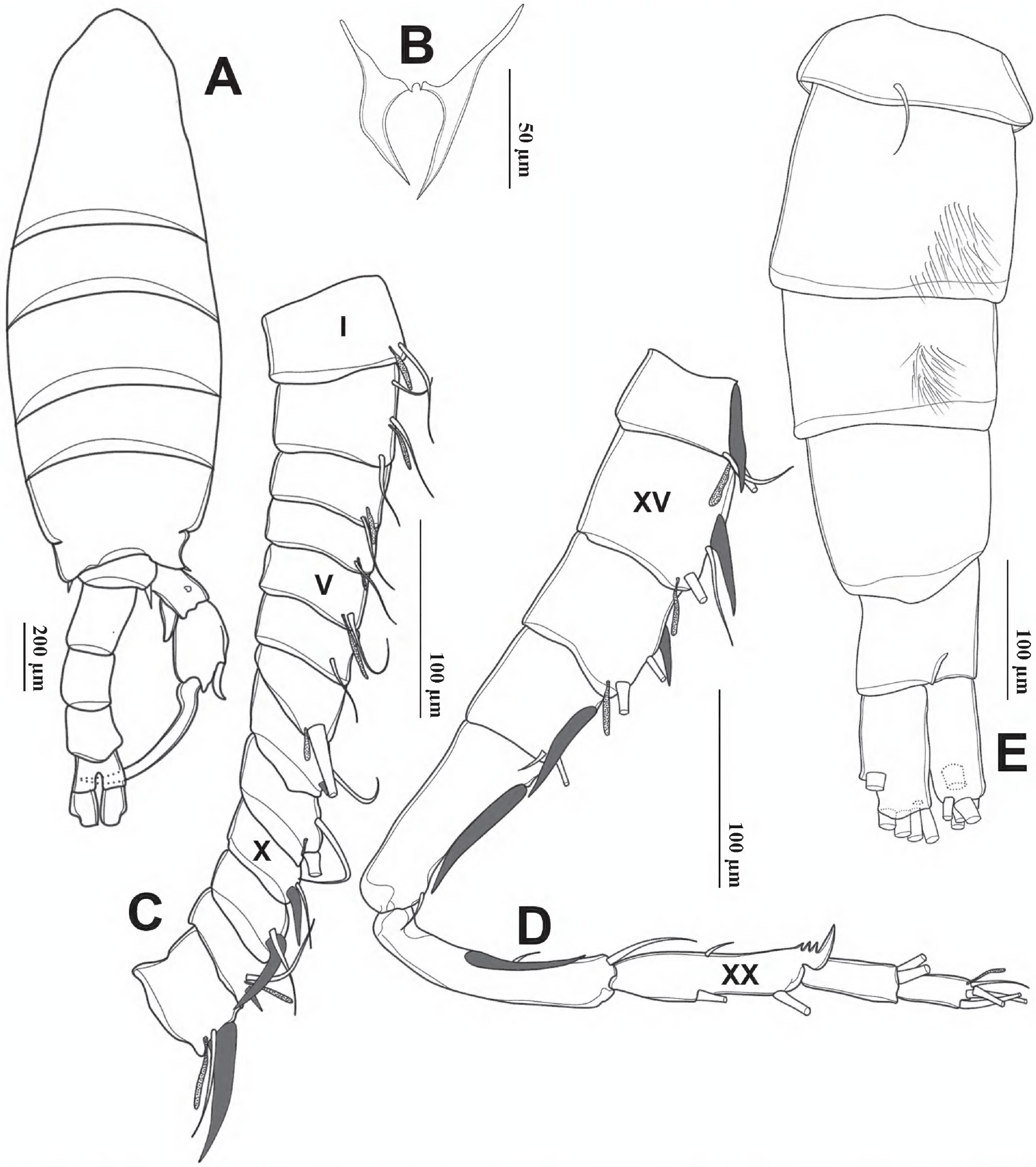


Figure 2. *Mongolodiaptomus nakhonphanomensis* sp. nov., adult male (holotype): **A.** Habitus, dorsal view; **B.** Rostrum; **C, D.** Right antennule, segments 1–13 and 14–21, respectively; **E.** Urosome, ventrolateral view.

seta on outer distal margin on right side. Urosomites 2–3 each with long hairs on mid-ventral surface; former somite longer than latter. Urosomite 4 with right posterolateral margin dilated; dorsoposterior margin expanded, overlapping part of following somite. Anal somite symmetrical; anal operculum small, with posterior margin slightly concave. Caudal rami (Fig. 2A, E) symmetrical; each ramus expanded distally, with setules along both inner and outer margins; with six setae (setae II–VII): setae II–VI plumose, seta VII bare. Right ramus without chitinous processes or ventral prominences.

Antennules asymmetrical, with the right antennule transformed and geniculated, exhibiting sexual dimorphism. Right side antennula (Fig. 2C, D) 22-segmented. Setal formula: 1+a (I), 3+a (II), 1+a (III), 1+a (IV), 1+a (V), 1 (VI), 1+a (VII), 1+s (VIII), 2+a (VIX), 1+s (X), 1+s (XI), 1+a+s (XII), 1+a+s (XIII), 2+a+s (XIV), 2+a+s (XV), 2+a+s (XVI), 2+s (XVII), 1+s (XVIII), 2+s (XIX), 3+s (XX), 2 (XXI), 4+a (XXII). Segments 13 to 20 enlarged and elongated; segments 18 and 19 geniculated; segment 20 (antepenultimate) with comb-like process (four teeth). Left side antennula (Fig. 4A) 25-segmented, reaching be-

Figure 3. *Mongolodiaptomus nakhonphanomensis* sp. nov., light microscope photograph of P5 male, posterior view.

yond the caudal setae. Setal formula as follows: 1+a (I), 3+a (II), 1+a (III), 1 (IV), 1+a (V), 1 (VI), 1+a (VII), 1+s (VIII), 2+a (IX), 1 (X), 1 (XI), 1+a+s (XII), 1 (XIII), 1+a (XIV), 1 (XV), 1+a (XVI), 1 (XVII), 1 (XVIII), 1+a (XIX), 1 (XX), 1 (XXI), 2 (XXII), 2 (XXIII), 2 (XXIV), 4+a (XXV).

Antenna (Fig. 4B): coxa with one seta on inner side; basis with two setae on inner distal margin. Exp seven-segmented, with 1, 3, 1, 1, 1, 1, 1 setae laterally, three setae apically. Enp two-segmented; Enp-1 with two setae at 1/2 length, Enp-2 with nine setae along inner margin and seven setae apically, accompanied by short row of spinules on distal outer margin.

Mandible (Fig. 4C): coxa with five bi-cuspidate teeth and one blunt tooth on gnathobase; with small dorsal seta on distolateral corner. Basis with four setae along inner margin. Enp two-segmented; Enp-1 with four setae on distal inner corner. Enp-2 with nine setae apically, accompanied by row of spinules along outer margin. Exp 4-segmented, with 1, 1, 1, and 3 setae, respectively.

Maxillule (Fig. 4D): praecoxal arthrite with ten robust setae apically and four fine setae on dorsal side. Coxal endite with three fine setae; coxal epipodite with eight robust setae. Basis with two endites, each armed with four setae; basal exite with one small seta. Enp reduced, represented by eight setae apically. Exp with seven apical setae.

Maxilla (Fig. 4E): proximal and distal praecoxal endites with four and three setae, respectively. Two coxal endites with three setae each. Allobasis with three setae on basal endite. Enp two-segmented, each with three setae.

Maxilliped (Fig. 4F): coxa with four endites, bearing 1, 2, 3 and 4 setae, respectively. Basis with three setae distally plus row of strong spinules along inner margin. Enp six-segmented, with 2, 3, 2, 2, 2 and 4 setae, respectively.

P1–P4 (Fig. 5A–D). P1 with two-segmented Enp and three-segmented Exp; P2–P4 with three-segmented Enp and Exp; Exp longer than Enp. Coxa on P1–P4 with pinnate seta at distal inner corner. P4 basis with small seta at distal outer margin. Exp-1 P1–P4 with one robust spine on outer margin and pinnate seta on inner margin. Exp-2 as Exp-1, but P1 without spine on outer margin. Exp-3 with three pinnate setae on inner margin and three pinnate setae apically on P2–P4, but two on P1 inner margin. Enp-1 P1–P4 with one pinnate seta on inner margin. P1 Enp-2 with three setae on inner margin, two setae apically, one pinnate seta on outer margin. P2–P4 Enp-2 with two pinnate setae on inner margin. Enp-3 P2–P4 with three setae on inner margin, two setae apically and two pinnate setae on outer margin.

P5 (Figs 3, 5E, F) asymmetrical, with right leg markedly enlarged. Intercoxal plate with rounded distal margin. Right side of P5: coxa with spiniform seta on posterior lobe, not reaching mid-length of basis. Basis approximately twice as long as wide, with narrow hyaline lamella along proximal inner margin and hyaline prominence at mid-distal region; with small seta at 3/4 length of outer margin. Exp three-segmented: Exp-1 shorter than wide, with unproduced distal outer corner and semicircular hyaline prominence distally. Exp-2 elliptical, with distal portion broader than proximal one, about 2.5 times as long as wide; with strong blunt spine at 1/2 length of outer margin and blunt process distally. Spine curved backwards, slightly shorter than half segment length. Exp-3 as sickle-shaped claw, about 1.5 times as long as Exp-2; with inner margin serrated. Enp 1-segmented, conical, gradually tapering distally, reaching the mid-length of Exp-2; with spinulated tip. Left side of P5: coxa with thin seta at distal inner margin, reaching beyond mid-half of basis. Basis with narrow hyaline lamella along distal inner margin; with short, thin posterolateral seta on outer margin. Exp three-segmented (Fig. 5E, F): Exp-1 longer than wide, gradually tapering in posterior end; with a hair field at distal half of inner margin. Exp-2 oval, smaller than Exp-1; with inner robust seta, accompanied by spinular field along inner margin. Exp-3 reduced to a short, bare segment with rounded tip. Enp one-segmented, conical, gradually tapering distally; reaching end of Exp-1, with spinulate tip.

Adult female. Body length excluding caudal setae 2.5 mm (allotype) (other females: mean = 2.3, n = 3) (Fig. 6A). Antennules symmetrical, with setal formula identical to that of the left antennule of male. Antenna and mouth appendages as in male. Cephalosome and pediger 1, as well as pedigers 4 and 5, completely fused. Pediger 5 (Figs 6A, 7B) with asymmetrical posterolateral wings: right wing short, rounded, with strong large spine dorsally, tiny spine on posterior margin; left wing longer, subtriangular, with tiny spine dorsally, larger spine poste-

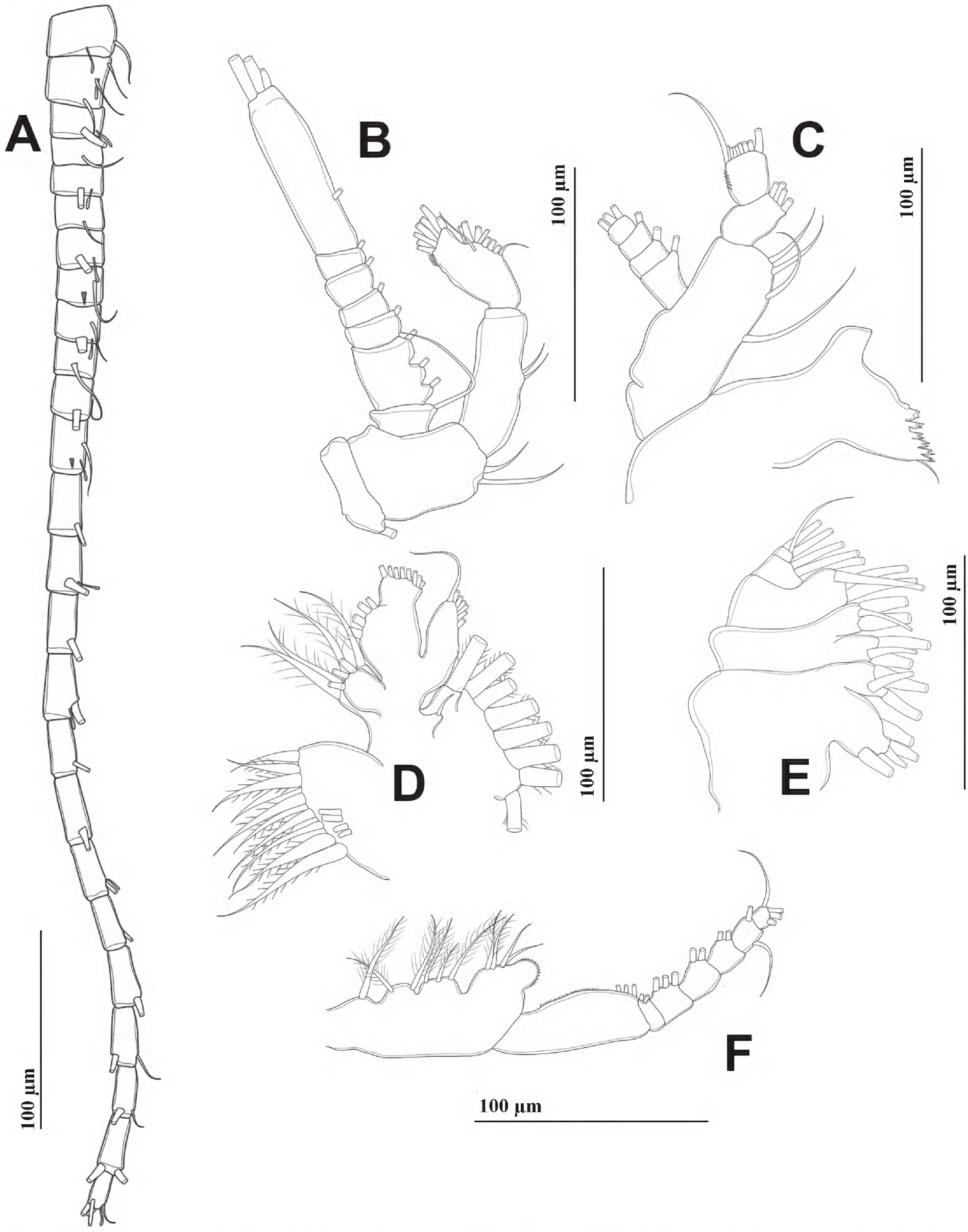


Figure 4. *Mongolodiaptomus nakhonphanomensis* sp. nov., adult male (holotype): **A.** Left antennule; **B.** Antenna; **C.** Mandible; **D.** Maxillule; **E.** Maxilla; **F.** Maxilliped.

riorly. Urosome (Fig. 7A) three-segmented; genital double-somite longer than two subsequent urosomites and caudal rami combined. Genital double-somite (Fig. 7A) asymmetrical; left side broadly expanded laterally at the proximal part, with strong spine; right side with proximal part slightly expanded laterally. Both spines articulated, inserted on somite prominence. Urosomite 2 symmetrical, shorter than wide, partly covered by posterior end of genital double-somite. Anal somite and caudal rami as in male (Fig. 7A).

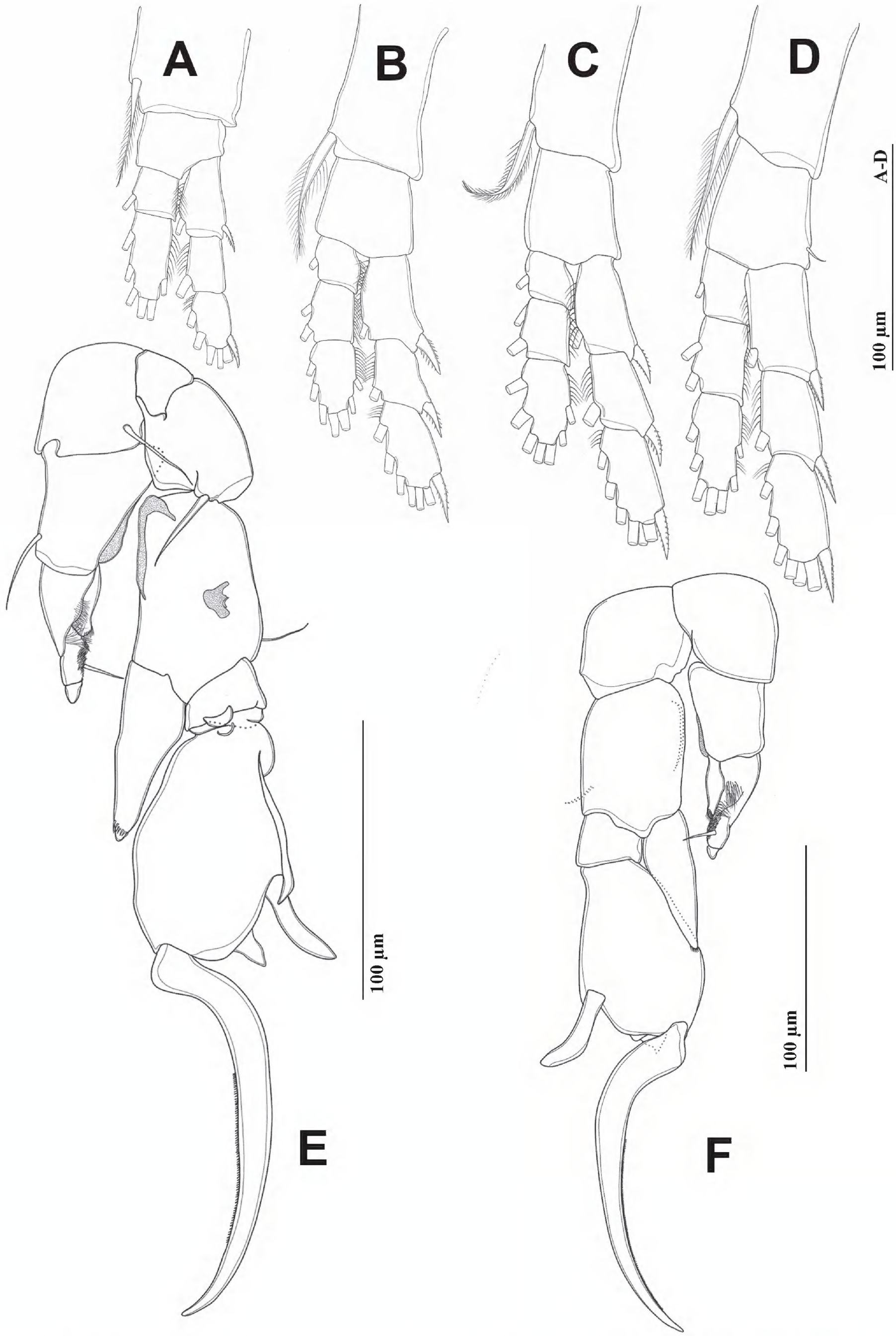


Figure 5. *Mongolodiaptomus nakhonphanomensis* sp. nov., adult male (holotype): **A.** P1; **B.** P2; **C.** P3; **D.** P4; **E.** P5, posterior view; **F.** P5, frontal view.

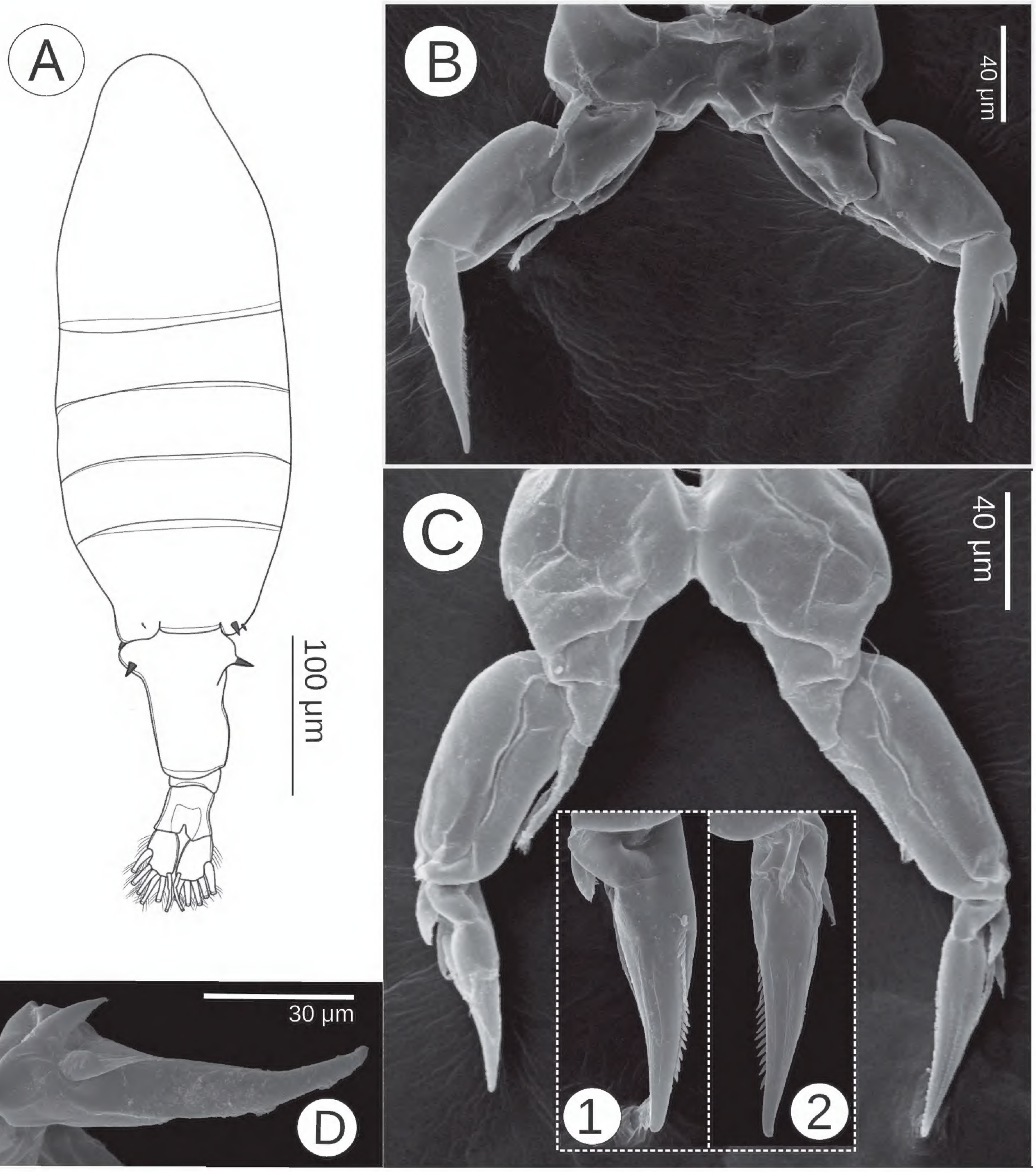


Figure 6. *Mongolodiaptomus nakhonphanomensis* sp. nov., line drawing and SEM photographs of adult female: **A.** Habitus, dorsal view; **B.** P5, posterior view; **C.** P5, frontal view (1 = right side of Exp-2, 2 = left side of Exp-2); **D.** Right P5 Exp-2–3, posterior view.

P5 (Figs 6B, C, 7C, D) asymmetrical. Coxa with a stout spine on a prominence at the distolateral corner in dorsal view; coxal spine reaching proximal margin of Exp-1. Basis with thin seta at 1/2 length of outer margin. Exp three-segmented, Enp two-segmented. Exp-1 rectangular, about twice as long as wide. Exp-2 triangular: right side shorter and stouter than left side (Fig. 6C1–2); inner margin with row of strong spinules; two longitudinal ridges ventrally; distal lateral seta strongly modified into short, stout spine (Fig. 6D). Exp-3 reduced to short, stout spine and long, thin seta. Enp cylindrical, extending beyond half-length of Exp-1. Enp-1 shorter than Enp-2; Enp-2 with circular row of spinules at narrowed apical end.

Variations. In addition to body size differences, segment 20 of the right antennule in males have a comb-like process with two to five teeth (Fig. 2D). The female P5 Enp varies in length, extending from the middle to the distal end of Exp-1. The size of the hyaline lamella on the right male P5 basis also varies, appearing in long and narrow on the inner margin and rounded (Fig. 5E) in the proximal-distal region.

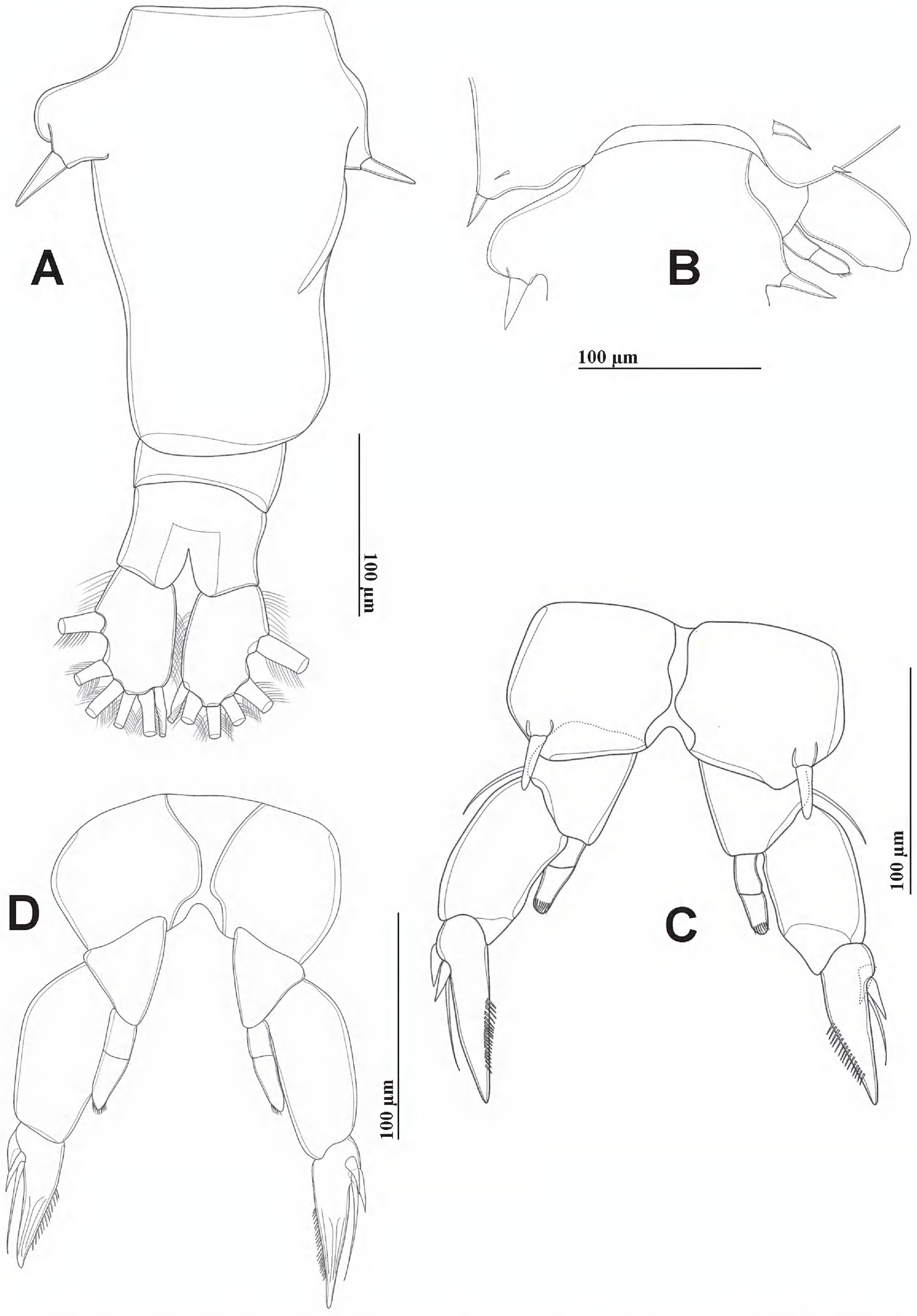


Figure 7. *Mongolodiaptomus nakhonphanomensis* sp. nov., adult female (allotype): **A.** Urosome, dorsal view; **B.** Pediger 5 and part of genital double-somite, dorsal view; **C.** P5, posterior view; **D.** P5, frontal view.

Ecology and distribution. At present, the new species has been recorded in seven samples, all collected from the Nawa District, Nakhon Phanom Province. It occurs in both temporary and permanent waterbodies. Physical and chemical parameters during sampling were: pH 6.2–7.01, temperature 27.2–31.2 °C, conductivity 14.73–108.6 µS/cm, total dissolved solids (TDS) 7.34–52.5 mg/l. The co-occurring copepod species include *Dentodiaptomus javanus* (Grochmalicki, 1915), *Eodiaptomus draconisignivomi* Brehm, 1952, *E. phuphanensis* Sanoamuang, 2001, *Heliodiaptomus elegans* Kiefer, 1935, *Mongolodiaptomus dumonti* Sanoamuang, 2001, *M. malaindosinensis* (Lai & Fernando, 1978) and *Neodiaptomus yangtsekiangensis* Mashiko, 1951.

Mongolodiaptomus pectinidactylus (Shen & Tai, 1964)

Figs 8, 9

Sampling sites. Samples were collected from four ponds in the Lao Pattana Village, Lao Pattana Sub-district, Na Wa District, Nakhon Phanom Province, north-eastern Thailand. The coordinates and elevations are as follows: 1) 17°35'4.59"N, 104°05'9.56"E, 151 m above sea level; 2) 17°35'0.15"N, 104°06'0.25"E, 152 m above sea level; 3) 17°34'6.05"N, 104°06'4.47"E, 147 m above sea level; 4) 17°35'6.71"N, 104°05'3.24"E, 155 m above sea level.

Material examined. Four adult males, each dissected and mounted on separate slide (NPU 2025–05–08); three adult females prepared for scanning electron microscopy (SEM) imaging. All specimens were collected on 4 August 2023 by Piyathida Monongdern.

Adult male. Urosomites 2–3 with hairs on ventral side. Caudal rami symmetrical, without chitinous prominence on right ramus ventrally. P5 (Figs 8A, 9A, B) asymmetrical, intercoxal plate with rounded distal margin. Right side of P5: coxa with spiniform seta inserted on distal margin dorsally, not reaching mid-length of basis. Basis about twice as long as wide, with narrow hyaline lamella along proximal inner margin and hyaline prominence at middle of segment dorsally; row of tiny spinules on ventral surface (Fig. 8B); small seta at 2/3 of segment length on ventral side. Exp three-segmented: Exp-1 shorter than wide, with unproduced distal outer corner and semicircular hyaline prominence distally. Exp-2 (Fig. 8C, D) elongated, with broader middle part, about 2.5 times as long as wide; with blunt-tipped spine at 1/2 length of outer margin and blunt process distally; spine straight, shorter than half of segment length. Exp-3 modified as sickle-shaped end claw with serrated inner about 1.5 times as long as Exp-2. Enp one-segmented, conical, not reaching the mid-length of Exp-2; with spinulated tip. Left side of P5: coxa with thin seta at distal inner margin, reaching to mid-half of basis. Basis with narrow hyaline lamella along distal inner margin; with short, thin posterolateral seta on outer margin. Exp three-segmented: Exp-1 longer than wide, gradually tapering in posterior end; with hair field at distal half of inner margin; Exp-2 oval, smaller than Exp-1; with inner robust seta, accompanied by spinular field along inner margin. Exp-3 reduced to short, bare segment with rounded tip. Enp one-segmented, conical, gradually tapering distally; not reaching end of Exp-1, with spinulate tip.

Adult female. Pediger 5 with almost symmetrical posterolateral wings; dorsal spine smaller than posterior spine on both wings. Genital double-somite asymmetrical; left side broadly expanded laterally at proximal part and with larger spine. Both spines on genital double-segment articulated, inserted on small somite prominence and directed down-laterally. Right margin concave, left margin convex. Anal somite and caudal rami as in male. P5 (Fig. 8E) symmetrical. Coxa with stout spine on prominence at distolateral corner in dorsal view; coxal spine reaching proximal margin of Exp-1. Basis with thin seta on distolateral margin in dorsal view, reaching beyond middle of Exp-1. Exp three-segmented and Enp two-segmented. Exp-1 enlarged, rectangular, more than 2.0 times as long as wide. Exp-2 (Fig. 8F, G) subtriangular, symmetrical, both margins with row of strong spinules; two longitudinal ridges visible in ventral view; distal lateral seta modified into short, stout spine. Exp-3 reduced to small spine, fused to base of Exp-2 accompanied by one short and one long, thin seta. Enp subconical, extending beyond half-length of Exp-1. Enp-1 shorter than Enp-2; Enp-2 with circular row of spinules at narrowed apical end.

Variations. The male right P5 basis has one or two rows of tiny spinules amongst individuals in the population (Figs 8B, 9B).

Distribution. *Mongolodiaptomus pectinidactylus* has been sporadically recorded across China, Vietnam and Thailand (Sanoamuang and Dabseepai 2021). In Thailand, it was previously reported from only two localities in the Roi Et and Ubon Ratchathani Provinces (Sanoamuang 2002). More recently, additional records have been reported from the Sakon Nakhon and Nakhon Phanom Provinces (Koompoot and Watiroyram 2025). The species has been found in both temporary and permanent waterbodies (Sanoamuang and Dabseepai 2021), similar to the observations made in the present study.

Differential diagnosis. Compared to the generic diagnoses by Kiefer (1938) and Ranga Reddy et al. (2000), the new species is assigned to the genus *Mongolodiaptomus*, based on the following characters: (1) urosomites 2–3 of the male with hairs on the ventral surface; (2) the presence of a spiniform seta on the male P5 coxa; (3) the lateral spine on the right male P5 Exp-2 inserted at the 1/2 length of outer margin, accompanied by two accessory spines. The male P5 intercoxal sclerite is rounded and unproduced, differing from the condition described by Kiefer (1938), but similar to that observed in *M. calcarus*, *M. dumonti*, *M. gladiolus*, *M. mephistopheles* and *M. pectinidactylus*. Additionally, the male lacks a chitinous prominence on the ventral side of the right caudal ramus, which also contrasts with Kiefer's (1938) description.

The new species is distinguished from its congeners by the distinctive morphology of the right male P5 Exp-2 and the right caudal ramus, as well as by the absence of a chitinous prominence on the ventral side of the right caudal ramus. This combination of characters makes the new

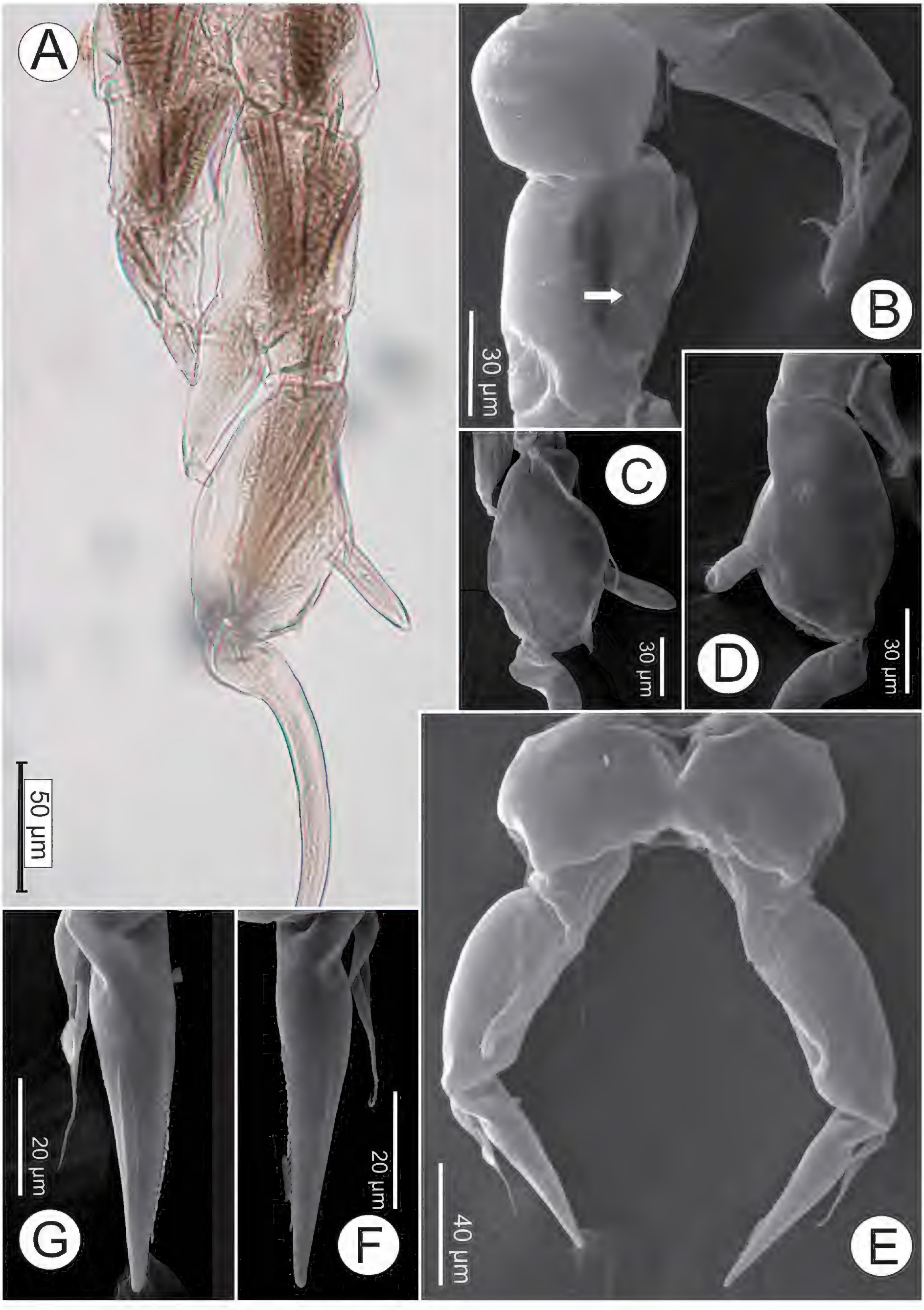


Figure 8. *Mongolodiaptomus pectinidactylus* (Shen & Tai, 1964), light microscope and SEM photographs of adult male (**A–D**) and female (**E–G**): **A.** P5, posterior view; **B.** Right P5 coxa and basis and left P5 Exp and Enp, frontal view; **C.** Right P5 Exp-2, posterior view; **D.** Right P5 Exp-2, frontal view; **E.** P5, frontal view; **F.** Right P5 Exp-2–3, frontal view; **G.** Left P5 Exp-2–3, frontal view.

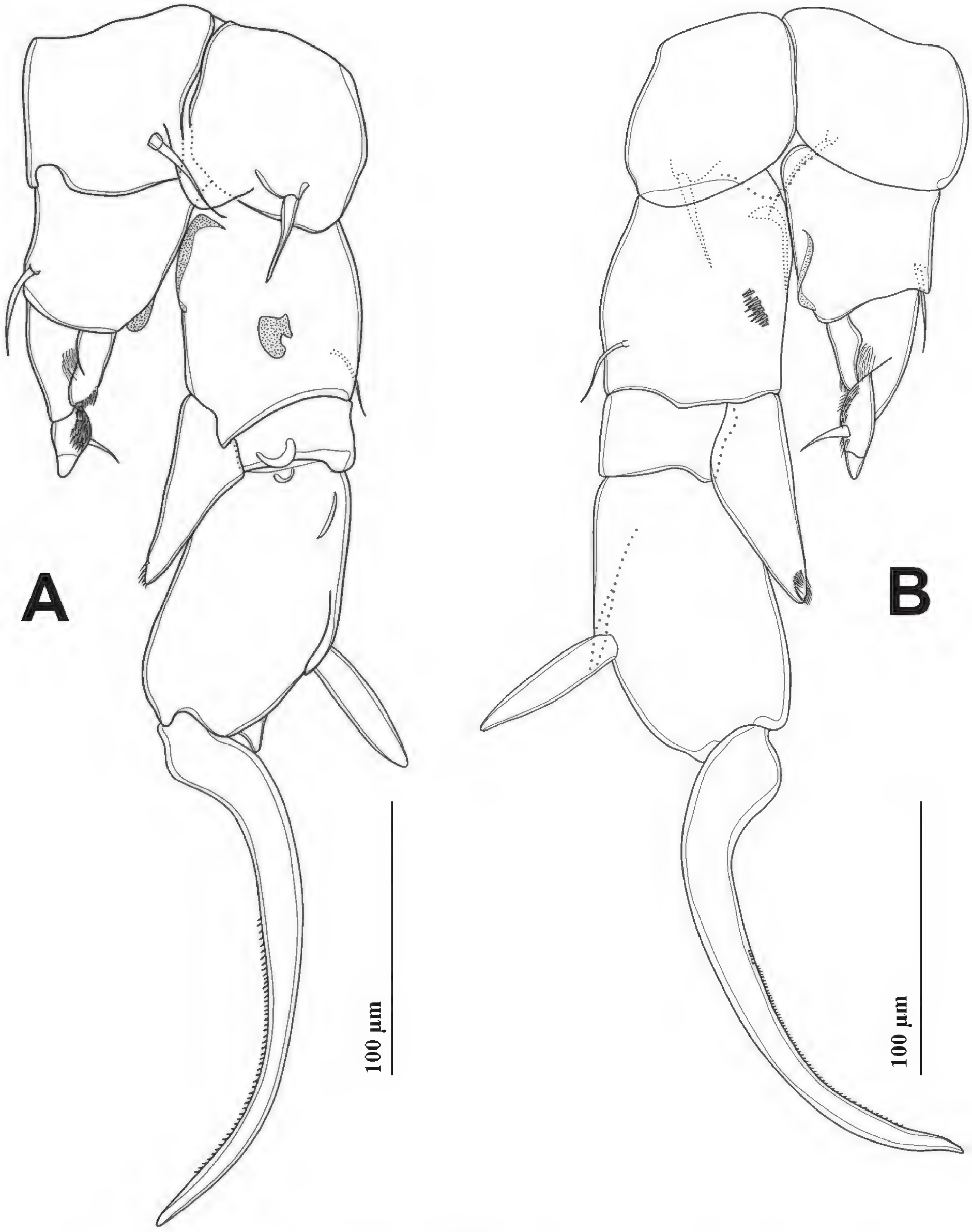


Figure 9. *Mongolodiaptomus pectinidactylus* (Shen & Tai, 1964), adult male: **A.** P5, posterior view; **B.** P5, frontal view.

species most similar to *M. pectinidactylus*, a member of the *M. mephistopheles* (Brehm, 1933) species group sensu Sanoamuang and Watiroyram (2018) and Sanoamuang and Koompoot (2024). Based on traditional taxonomy, particularly the morphology of pediger 5 in females, the urosome and the P5 in both sexes, the species can be distinguished from *M. pectinidactylus* as follows: the female of the new species has an asymmetrical lateral wing on pediger 5, with the right dorsal spine and the left posterior spine being larger than those of *M. pectinidactylus*. Additionally, the female P5 is asymmetrical, featuring a longer left Exp-2 and a stouter right Exp-2, whereas the P5 is

symmetrical in *M. pectinidactylus*. The seta on the female P5 Exp-2 is also distinctly shorter and stouter compared to that of *M. pectinidactylus*. The male of the new species lacks a row of spinules on the frontal surface of the P5 basis, whereas this feature is present in *M. pectinidactylus*. In addition, the male P5 Exp-2 of the new species is slightly more distally expanded than that of *M. pectinidactylus* and the lateral spine is bent outwards, in contrast to the straight spine in *M. pectinidactylus* (Table 2).

Discussion

The genus *Mongolodiaptomus* Kiefer, 1937, was established after Kiefer (1937) found that *M. formosanus* Kiefer, 1937, was morphologically more similar to the Oriental genera *Allodiaptomus* Kiefer, 1936 and *Phyllodiaptomus* Kiefer, 1936, than to *Eudiaptomus* Kiefer, 1932, which is widely distributed in the Holarctic Region. He also re-allocated *E. birulai* (Rylov, 1922) to the new genus as *M. birulai*. Later, Kiefer (1938) provided a more detailed generic diagnosis and designated *M. birulai* as the type species. According to Kiefer (1937, 1938), *M. formosanus* and *M. birulai* are distinct species, as he provided detailed descriptions of their differentiated morphological traits. These two species are listed as distinct in the World Copepoda database (Walter and Boxshall 2025). In contrast, *M. formosanus* has been considered a synonym of *M. birulai* (Shen et al. 1979; Young and Shih 2011; Young et al. 2013; Tran et al. 2016; Li et al. 2018; Sanoamuang and Koompoot 2024). Unfortunately, no figures or detailed descriptions are available to definitively clarify the taxonomic status of these two species. Therefore, further studies are needed. In the present study, we treat both species according to the original concept of Kiefer (1937, 1938). Thus, there are 15 valid species, including the new species described herein (Table 3).

Based on the World of Copepods database, the nominal and synonymised species names within the genus *Mongolodiaptomus* are summarised in Table 3. The genera *Eudiaptomus* and *Diaptomus* Westwood, 1836 are primarily distributed in the Holarctic Region (Dussart and Defaye 2002; Podshivalina et al. 2022). At that time, some Oriental species remained classified under *Diaptomus sensu lato* due to insufficient morphological or taxonomic information to assign them to more appropriate genera. The genus *Heliodiaptomus* Kiefer, 1932 is primarily found in the Oriental Region, with a strong presence in South Asia and parts of Southeast Asia. It is one of the genera that was established to accommodate a group of Oriental species formerly placed in *Diaptomus sensu lato* (Ranga Reddy and Radhakrishna 1981). In Southeast Asia, several diaptomid genera, such as *Allodiaptomus* Kiefer, 1936, *Heliodiaptomus* Kiefer, 1932, *Neodiaptomus* Kiefer, 1932 and *Phyllodiaptomus* Kiefer, 1936, are often misidentified due to their morphological similarity to *Mongolodiaptomus*, especially *Allodiaptomus* and *Neodiaptomus*. Due to this, Ranga Reddy et al. (2000) amended

Table 2. Key morphological differences within the *M. mephistopheles* (Brehm, 1933) species group of the genus *Mongolodiaptomus*.

Characters		*M. mephistopheles*	*M. pectinidactylus*	*M. uenoi*	*M. nakhonphanomensis* sp. nov.
Male					
Urosomites 2–3 (ventral view)		Without hairs?	With hairs	With hairs	With hairs
Right caudal ramus (ventral view)		With chitinous prominence	Without chitinous prominence	With chitinous prominence	Without chitinous prominence
P5 intercoxal sclerite (distal margin)		round	round	Spine-like process	round
Right P5	basis	Without chitinous prominence	With chitinous prominence	Without chitinous prominence	With chitinous prominence
	Exp-1 (distal outer corner)	produced	unproduced	produced	unproduced
	Exp-2 (shape)	Rectangular (proximal slightly more expanded that distal)	Oblong	Rectangular (proximal slightly more expanded that distal)	Oblong (distal expanded)
	Exp-2 (principal spine)	Long, slender	Short, straight and sturdy	Short, straight and sturdy	Short, bent outward and sturdy
	Exp-2 (proximal accessory spine)	Middle	Middle	Proximal	Middle
Left P5 basis (frontal view)		Without spinules?	With spinules	Without spinules	Without spinules
Female					
Lateral wing		Asymmetrical	Symmetrical	Asymmetrical	Asymmetrical
Genital double-somite		Without right posterior process	Without right posterior process	With right posterior process	Without right posterior process
P5		Symmetrical?	Symmetrical	Symmetrical	Asymmetrical
	Exp-2 (lateral seta)	With normal seta?	With short and moderately stout seta	With normal seta	With short, stout seta
	Exp-2 (frontal view)	Without longitudinal ridge?	With longitudinal ridge	Without longitudinal ridge	With longitudinal ridge

Table 3. Summary of the nominal and synonymised species names within the genus *Mongolodiaptomus* Kiefer, 1937, as well as those of related genera: *Allodiaptomus* Kiefer, 1936; *Diaptomus* Westwood, 1836; *Eudiaptomus* Kiefer, 1932; *Heliodiaptomus* Kiefer, 1932; *Neodiaptomus* Kiefer, 1932; and *Phyllodiaptomus* Kiefer, 1936.

Specific name	Original name (type locality)	Synonym name (s)
1. *M. birulai* (Rilov, 1922)	*Diaptomus birulai* Rilov, 1922 (China)	*Eudiaptomus birulai* (Rilov, 1922); *Heliodiaptomus buldovskii* Rylov, 1930; *M. amurensis* Borutzky, 1961; *M. buldovskii* (Rylov, 1936)
2. *M. botulifer* Kiefer, 1974	*Neodiaptomus botulifer* Kiefer, 1974 (Malaysia)	*D. visnu* Daday, 1906; *Phyllodiaptomus visnu* (Daday, 1906)
3. *M. calcarus* (Shen & Tai, 1965)	*Allodiaptomus calcarus* Shen & Tai, 1965 (China)	-
4. *M. dumonti* Sanoamuang, 2001	*M. dumonti* Sanoamuang, 2001 (Thailand)	-
5. *M. formosanus* Kiefer, 1937*	*M. formosanus* Kiefer, 1937 (Taiwan)	-
6. *M. gladiolus* (Shen & Lee, 1963)	*A. gladiolus* Shen & Lee, 1963 (China)	-
7. *M. loeiensis* Watiroyram & Sanoamuang, 2017	*M. loeiensis* Watiroyram & Sanoamuang, 2017 (Thailand)	-
8. *M. malaindosinensis* (Lai & Fernando, 1978)	*N. malaindosinensis* Lai & Fernando, 1978 (Malaysia)	-
9. *M. mekongensis* Sanoamuang & Watiroyram, 2018	*M. mekongensis* Sanoamuang & Watiroyram, 2018 (Thailand)	-
10. *M. mephistopheles* (Brehm, 1933)	*N. mephistopheles* Brehm, 1933 (Indonesia)	-
11. *M. nakhonphanomensis* sp. nov.	*M. nakhonphanomensis* sp. nov. (Thailand)	-
12. *M. pectinidactylus* (Shen & Tai, 1964)	*A. pectinidactylus* Shen & Tai, 1964 (China)	-
13. *M. phutakaensis* Sanoamuang & Koompoot, 2024	*M. phutakaensis* Sanoamuang & Koompoot, 2024 (Thailand)	-
14. *M. rarus* (Ranga Reddy et al., 1998)	*A. rarus* Ranga Reddy et al., 1998 (Thailand)	-
15. *M. uenoi* (Kikuchi, 1936)	*D. uenoi* Kikuchi, 1936 (Taiwan)	*A. uenoi* (Kikuchi, 1936); *N. uenoi* (Kikuchi, 1936)
16. *M. amurensis* Borutzky, 1961**	*M. amurensis* Borutzky, 1961 (USSR)	-
17. *M. buldovskii* (Rylov, 1930)**	*Heliodiaptomus buldovskii* Rylov, 1930 (USSR)	-
18. *M. mariadvigae* (Brehm, 1921)**	*D. mariadvigae* Brehm, 1921 (China)	*E. mariadvigae* (Brehm, 1921); *M. mariadvigae* (Brehm, 1921); *Ligulodiaptomus mariadvigae* (Brehm, 1921)
19. *M. subquadratus* Shen & Song, 1965**	*M. subquadratus* Shen & Song, 1965 (China)	-

* = Taxonomic status is doubtful and requires revision; ** = currently regarded as a junior synonym: *M. amurensis* Borutzky, 1961 = *M. birulai* (Rilov, 1922); *M. buldovskii* (Rylov, 1936) = *M. birulai* (Rilov, 1922); *M. mariadvigae* (Brehm, 1921) = *Neutrodiaptomus mariadvigae* (Brehm, 1921); *M. subquadratus* Shen & Song, 1965 = *P. blanci* (Guerne & Richard, 1896).

the generic diagnosis, which resulted in the re-allocation of seven species into the genus, along with *M. birulai* (Rylov, 1922) and *M. formosanus* Kiefer, 1937. These species include *A. calcarus* Shen & Tai, 1965; *A. gladiolus* Shen & Lee, 1963; *A. pectinidactylus* Shen & Tai, 1964; *N. botulifer* Kiefer, 1974; *N. malaindosinensis* Lai & Fernando, 1978; and *N. mephistopheles* Brehm, 1933. Subsequently, *A. rarus* Ranga Reddy, Sanoamuang & Dumont, 1998 was also allocated to the genus by Sanoamuang (2002) and included in her later publications. The discovery of this new species demonstrates that the genus *Mongolodiaptomus* shares morphological similarities with the genus *Phyllodiaptomus*, as previously observed in the case of *M. botulifer* (Kiefer, 1974) and *P. visnu* (Daday, 1906) (Lai and Fernando 1978). The shape of the right P5 Exp-2, the position of the accessory spines and the caudal rami in males are similar between the new species and members of the genus *Phyllodiaptomus* – features that are not commonly observed in other *Mongolodiaptomus* congeners, except for *M. pectinidactylus*. The new species and *Phyllodiaptomus* species are mainly characterised by: (1) the P5 Exp-2 having a globular, oval, oblong or distally expanded outer shape; (2) the principal lateral spine on Exp-2 being thick, outcurved and inserted at the distal half of the outer margin; (3) an accessory lateral spine or lamella present at the distal outer corner or near the insertion point of the principal lateral spine; (4) the caudal rami being symmetrical, with the right ramus lacking a chitinous prominence. This is not surprising, as other features in recent descriptions of *Mongolodiaptomus* also exhibit characteristics typically associated with *Phyllodiaptomus*. For example, a serrate fan is present on the left male P5 Exp-2 in *M. mekongensis* and *M. phutakaensis* and a longitudinal ridge occurs on the female P5 Exp-2 in *M. phutakaensis* (Sanoamuang and Watiroyram 2018; Sanoamuang and Koompoot 2024).

This study summarises distribution of the genus *Mongolodiaptomus*, emphasising their records in Southeast Asia and south China (Table 4). The genus has limited distribution extension into East Asia, where only a few species have been recorded, likely due to insufficient sampling (Fig. 10A). Eleven out of the 15 species were found in north-eastern Thailand (Fig. 10B) and five species were discovered within the relatively small area surveyed

Table 4. Summary of the distribution of the genus *Mongolodiaptomus* Kiefer, 1937.

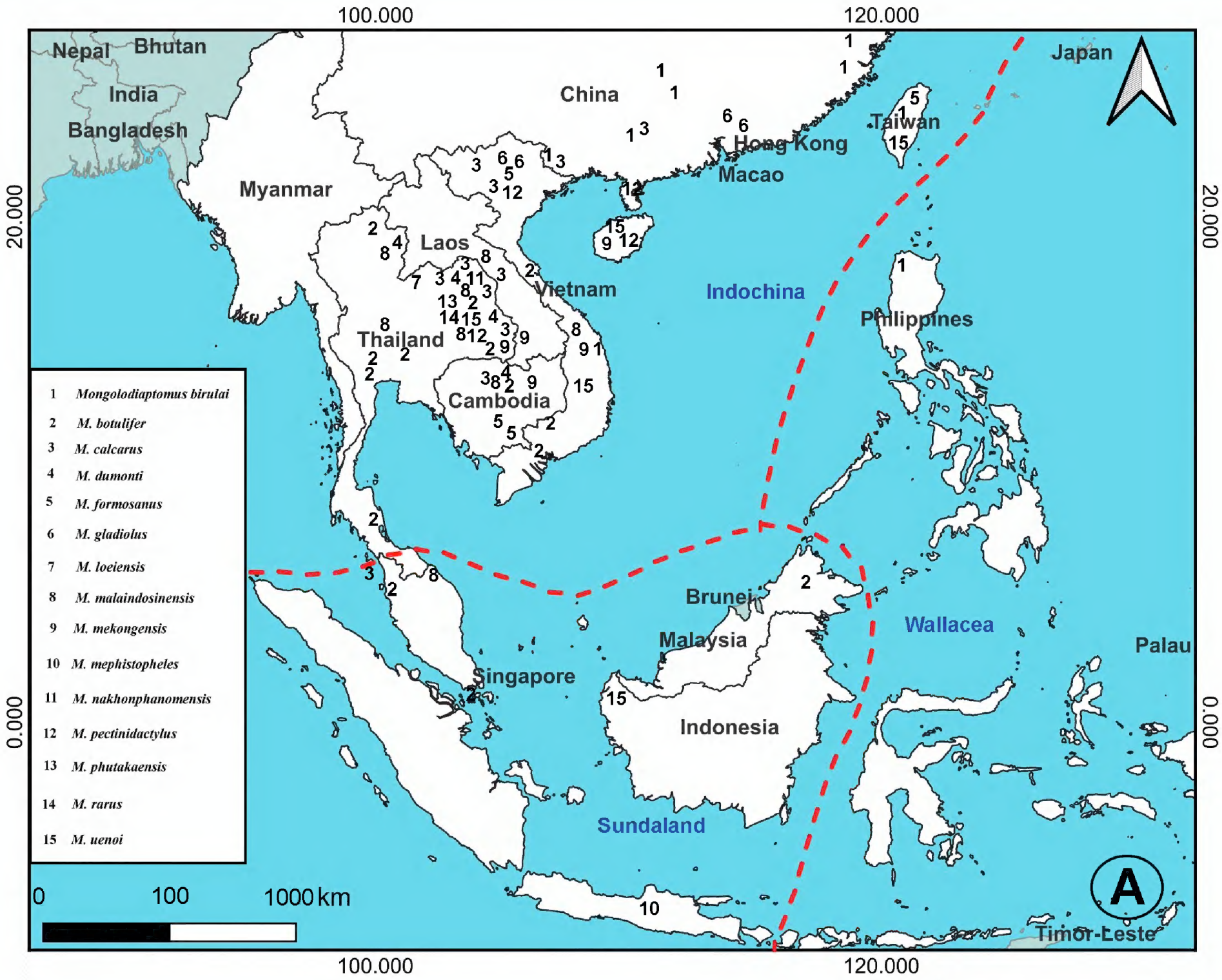
Species	Country	References
1. *M. birulai*	China[1], Philippines[2], Taiwan[3], Vietnam[4]	Rylov (1922)[1], Young et al. (2013)[3], Tran et al. (2016)[4,] Lopez et al. (2017)[2]
2. *M. botulifer*	Cambodia[8], Laos[6], Malaysia[1,2,4], Singapore[2,3], Thailand[6], Vietnam[5,7]	Kiefer (1974)[1], Lai and Fernando (1978)[2], Schmoker et al. (2014)[3], Alekseev (2016)[4], Tran et al. (2016)[5], Sanoamuang and Dabseepai (2021)[6], Boonmak and Sanoamuang (2022)[7], Chaicharoen and Sanoamuang (2022)[8]
3. *M. calcarus*	Cambodia[5], China[1,3], Laos[4], Thailand[4], Vietnam[2]	Shen and Tai (1965)[1], Tran et al. (2016)[2], Li et al. (2018)[3], Sanoamuang and Dabseepai (2021)[4], Chaicharoen and Sanoamuang (2022)[5]
4. *M. dumonti*	Thailand[1,2], Cambodia[3]	Sanoamuang (2001)[1], Sanoamuang and Dabseepai (2021)[2], Chaicharoen and Sanoamuang (2022)[3]
5. *M. formosanus*	Taiwan[1], Cambodia[3], Vietnam[2?]	Kiefer (1937)[1], Tran et al (2016)[2], Chaicharoen and Sanoamuang (2022)[3]
6. *M. gladiolus*	China[1,3], Vietnam[2]	Shen and Lee (1963)[1], Tran et al. (2016)[2], Li et al. (2018)[3]
7. *M. loeiensis*	Thailand[1,2]	Watiroyram and Sanoamuang (2017)[1], Koompoot and Watiroyram (2025)[2]
8. *M. malaindosinensis*	Cambodia[7], Laos[3], Malaysia[1,2,4], Thailand[6], Vietnam[5]	Lai and Fernando (1978)[1], Lai and Fernando (1978)[2], Sanoamuang (2002)[3], Umi et al (2020)[4], Sanoamuang and Dabseepai (2021)[6], Boonmak and Sanoamuang (2022)[5], Chaicharoen and Sanoamuang (2022)[7]
9. *M. mekongensis*	Cambodia[4], China[5], Laos[2,5], Thailand[1,2], Vietnam[3]	Sanoamuang and Watiroyram (2018)[1], Sanoamuang and Dabseepai (2021)[2], Boonmak and Sanoamuang (2022)[3], Chaicharoen and Sanoamuang (2022)[4], Wei et al. (2023)[5]
10. *M. mephistopheles*	Indonesia	Ranga Reddy et al. (1998), Alekseev et al. (2013)
11. *M. nakhonphanomensis* sp. nov.	Thailand	This study
13. *M. pectinidactylus*	China[1], Thailand[3], Vietnam[2]	Shen and Tai (1964)[1], Tran et al. (2016)[2], Sanoamuang and Dabseepai (2021)[3]
13. *M. phutakaensis*	Thailand	Sanoamuang and Koompoot (2024)
14. *M. rarus*	Thailand[1,2,3]	Ranga Reddy et a.l (1998)[1], Sanoamuang and Dabseepai (2021)[2], Koompoot and Watiroyram (2025)[3]
15. *M. uenoi*	China[6], Indonesia[2,3], Taiwan[1,2], Thailand[2,4], Vietnam[5]	Kikuchi (1936)[1], Ranga Reddy et al. (2000)[2], Alekseev et al. (2013)[3], Alekseev et al. (2016)[3], Sanoamuang and Dabseepai (2021)[4], Tran et al. (2016)[5], Li et al. (2018)[6]

in this study (*M. botulifer*, *M. dumonti*, *M. malaindosinensis*, *M. nakhonphanomensis* sp. nov., *M. pectinidactylus*). *Mongolodiaptomus* species are typically found in standing or slow-flowing waters, both in permanent and temporary inland waterbodies, where they are a component of the euzooplankton community. The distribution of *Mongolodiaptomus* species is largely confined to the Indo-malayan realm, with the exception of *M. birulai*, which extends into northern China within the Palaearctic realm. Their distribution is divided into three major subregions: the Indo-Chinese, Sundaland (Sundaric) and Wallacean subregions.

Species in the Indo-Chinese subregion

(1) *M. formosanus* was originally collected from reservoirs and rice fields in Taiwan. Unfortunately, the occurrence of this species in China, Vietnam and Cambodia is doubtful due to the species status (Tran et al. 2016; Li et al. 2018; Chaicharoen and Sanoamuang 2022); (2) *M. gladiolus* was originally described from rivers and deltaic habitats in Guangdong (Shen and Lee 1963) and was later reported from Guangxi, both localities situated in southern China (Li et al. 2018). Its distribution extends southwards into Bac Giang and Hai Duong Provinces, northern Vietnam, where it inhabits aquaculture ponds and river (Tran et al. 2016); (3) *M. dumonti* was originally found in various aquatic environments, including both temporary and permanent waterbodies, in north-eastern Thailand (Sanoamuang 2001). More recently, it has also been reported from the upper region of Cambodia (Chaicharoen and Sanoamuang 2022); (4) *M. botulifer*, (5) *M. calcarus* and (6) *M. malaindosinensis* are commonly found in aquatic environments across Southeast Asia, particularly in Cambodia, Malaysia, Thailand and Vietnam, which are well-studied regions (Lai and Fernando 1980; Ranga Reddy et al. 1998; Alekseev et al. 2016; Boonmak and Sanoamuang 2022; Chaicharoen and Sanoamuang 2022; Sanoamuang and Dabsepai 2021). Amongst these, only *M. calcarus* has been recorded as far south as the Langkawi Island and Negeri Sembilan in Malaysia. Its range also extends northwards from the Dien Bien and Hoa Binh in northern Vietnam to Guangdong and Guangxi in southern China, where the species was originally described (Tran et al. 2016; Li et al. 2018).

Four species are rare and endemic to Thailand; (7) *M. loeiensis* was originally described from temporary ponds in the Loei Province and was later reported from the Nong Khai Province in north-eastern Thailand (Watiroyram and Sanoamuang 2017; Koompoot and Watiroyram 2025); (8) *M. phutakaensis* was first discovered in a natural swamp in Khon Kaen Province (Sanoamuang and Koompoot 2024) and was later recorded in the author's collections from the Loei and Udon Thani Provinces (Watiroyram, personal observation); (9) *M. rarus* was described, based on one male



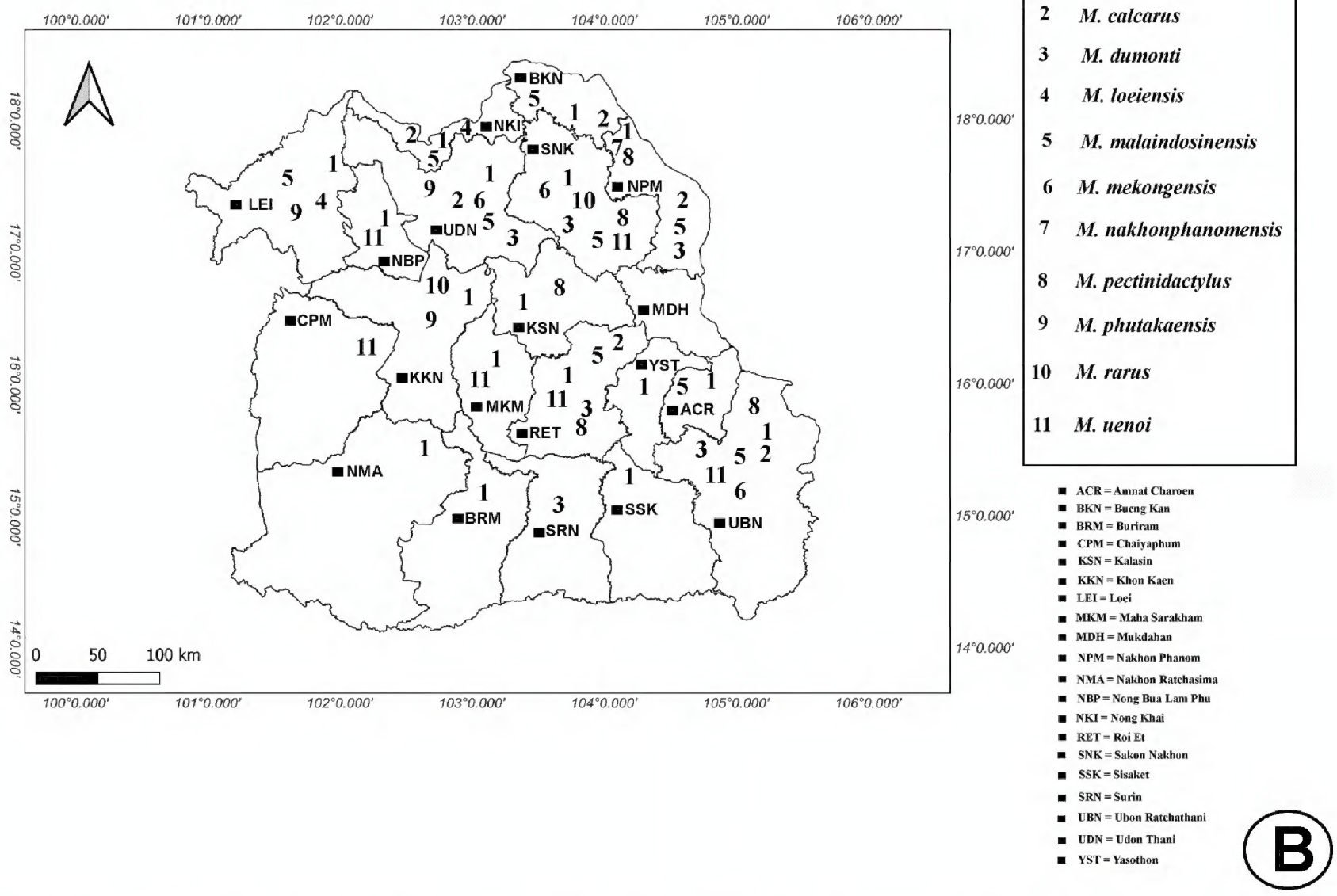


Figure 10. Distribution of the genus *Mongolodiaptomus* Kiefer, 1937: **A.** In southeast Asia and China; **B.** In north-eastern Thailand.

from an unspecified locality in Thailand, but its presence has been confirmed in roadside canal of the Sakon Nakhon Province, north-eastern Thailand (Ranga Reddy et al. 1998; Koompoot and Watiroyram 2025); (10) *M. nakhonphanomensis* sp. nov., was found from both temporary and permanent waterbodies in the Nakhon Phanom Province, north-eastern Thailand (the present study);

(11) *M. mekongensis* has been recorded from various types of waterbodies within the Mekong River system in north-eastern Thailand, Laos, Cambodia and southern Vietnam (Boonmak and Sanoamuang 2022; Chaicharoen and Sanoamuang 2022; Koompoot and Watiroyram 2025). In addition, it has been reported outside the Mekong River system from Hainan Island in southern China (Wei et al. 2023); (12) *M. pectinidactylus* was first described from the Hainan and later recorded from Guangdong, both in southern China (Shen and Tai 1964; Li et al. 2018). This species has been occasionally found in various types of waterbodies in four provinces of north-eastern Thailand (Sanoamuang 2002; Koompoot and Watiroyram 2025) and one province of northern Vietnam (Tran et al. 2016).

Species in the Sundaland (Sundaric) subregion

(13) *M. mephistopheles* was previously misidentified in Thailand and Malaysia, but it is actually endemic to Java (Indonesia) (Brehm 1933; Lai and Fernando 1978, 1980; Ranga Reddy et al. 1998).

Species in the Indo-Chinese and Wallacean subregions

(14) *M. birulai* was originally described from China and has been reported from several localities under the recorded name of *M. birulai* and *M. formosanus*, including northern (Hebei, Heilongjiang), eastern (Fujian, Jiangsu, Zhejiang), central and southern China (Guangdong, Guangxi, Hainan, Hunan) (Li et al. 2018). It was later reported from Taiwan (Young et al. 2013), Vietnam (Tran et al. 2016) and the Philippines (Lopez et al. 2017); (15) *M. uenoi* was first described from Taiwan (Kikuchi 1936); and subsequently reported from West Java and West Kalimantan, Indonesia (Lai and Fernando 1980; Ranga Reddy et al. 2000; Alekseev et al. 2013, 2016), Kon Tum and Dak Lak Provinces in central Vietnam (Tran et al. 2016) and Hainan Island in southern China (Li et al. 2018). However, due to incomplete morphological descriptions, the occurrence of this species in Indonesia remains uncertain (Ranga Reddy et al. 2000). In north-eastern Thailand, it was found in both temporary and permanent waterbodies within the Chi River Basin, specifically in Chaiyaphum, Kalasin and Nong Bua Lam Phu Provinces (Ranga Reddy et al. 2000). However, *M. uenoi* was not observed in the Songkhram, Mun and Mekong River Basins during the recent field surveys, where *M. mekongensis* was found to be dominant (Koompoot and Watiroyram 2025).

Conclusion

A total of 48 samples collected from Nawa District, Nakhon Phanom Province, yielded five of the eleven *Mongolodiaptomus* species known from Thailand. One of them, *M. nakhonphanomensis* sp. nov., is described herein. The new species is most similar to *M. pectinidactylus*, a member of the *M. mephistopheles* (Brehm, 1933) species group, as they share unique characteristics, such as the morphology of the right male P5 Exp-2 and the absence of a chitinous prominence on the right caudal ramus in males. However, they can be easily distinguished by the presence or absence of a row of spinules on the left P5 basis, the shape of the principal lateral spine on the right P5 Exp-2 in males, as well as the morphology of the lateral wings and P5 Exp-2 in females. At present, although both species were collected from the study area, they have never been found together at the same locality and the new species has been found more frequently than *M. pectinidactylus*. The distribution of species in the study area, along with the biogeographic map generated from published literature, suggests that the genus *Mongolodiaptomus* has a hotspot in the Indo-Chinese subregion, particularly in the Southeast Asia.

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